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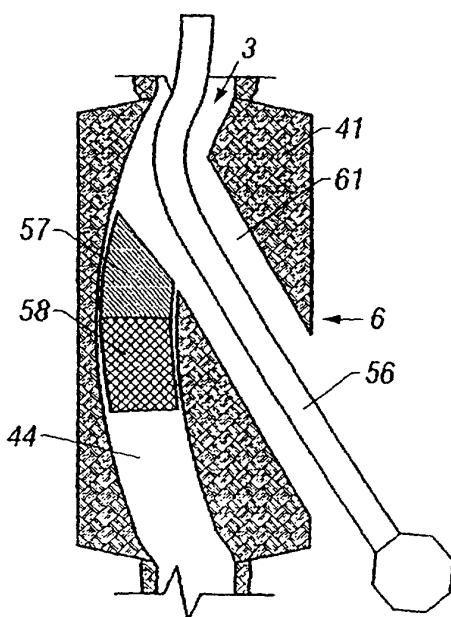
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(54) Title: IMPROVED METHOD FOR DRILLING MULTI-LATERAL WELLS AND RELATED DEVICE



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(57) Abstract: An improved method for drilling a lateral well (61) from an existing well-bore (3) whereby a section of it is underreamed, filled with epoxy, drilled out laterally, and completed with a sealed junction (6). More particularly, an improved method that facilitates the establishment of a lateral well (61) that is substantially the same size as the existing well-bore (3).

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Improved Method for Drilling Multi-Lateral Wells and Related Device

TECHNICAL FIELD

The present invention relates generally to an improved method for drilling multi-lateral wells and related device. More particularly, the present invention relates to an improved method for drilling one or more multi-lateral wells from an existing well whereby the junction about the lateral well is sealed.

RELATED APPLICATION

This is a related Application to another application entitled "Improved Method for Drilling Multi-Lateral Wells With Reduced Under-reaming and Related Device" filed on August 28, 2000.

BACKGROUND ART

Drilling or utilizing multi-lateral or horizontal wells has become increasingly popular for enhancing production and recovery of oil and gas from well-bores. Multi-lateral drilling methods have been known for a relatively short period of time and only recently have methods and apparatuses been developed to make the drilling of such wells cost-effective and technically sound to the oil industry.

However, drilling of multi-lateral wells is in increased demand because it has been shown that the economic viability from a multi-lateral well is dramatically increased when compared to that of conventional wells. As a result of an increased return on investment on oil and gas recovery, the drilling of multi-lateral wells has become an important aspect of well enhancement. As such, the drilling of multi-lateral wells has become very important for efficient oil and gas recovery. Multi-lateral wells have been found very effective in areas where the pay-zone or oil/gas deposit may be thin or hard to reach with standard down-hole drilling operations.

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However, one of the primary reasons an operator would drill a multi-lateral well is to take advantage of the existence of a previously drilled wellbore. In drilling a multi-lateral well, a driller can reduce the cost of the well dramatically by beginning the new drilling operations at a point already down from the surface. Therefore, many of the modern methods that have been developed attempt to make use of an existing well-bore and thereby eliminate the cost of drilling from the surface..

The technique of drilling a multi-lateral well has typically consisted of laterally drilling from a previous drilled borehole, sometimes referred to herein as the primary borehole. The previous drilled borehole from which a lateral well is drilled is typically cased and cemented, but methods exist in the art for un-cased and un-cemented well-bores. However, these prior art methods of drilling lateral boreholes suffer from a common problem of maintaining a sealed junction between the primary well-bore and the lateral well-bore. The present invention is an improved method for establishing and maintaining such sealed junction.

A common example of the prior art drilling methods is embodied in U.S. Pat. No. 5,458,209 to Hayes et al. (the '209 patent). The '209 patent discloses a method and system for drilling a lateral well with respect to a primary well which is cased. The method discloses positioning a guide means; defined as comprised of three main parts; a lower end, a central part with an angled ramp and an upper end., and drilling out the casing along the guide at a preselected location. This method has effectively drilled multi-lateral wells, but does not insure a sealed junction.

Accordingly, the art field is in search of a method to drill a lateral well and to establish a sealed junction about one portion of the lateral well, such as between the lateral well and the primary well-bore.

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A prior art method that has had some success in sealing the well-bore around the junction is disclosed in U.S. Pat. No. 5,564,503 to Longbottom et al (the '503 patent). This patent discloses a method of drilling a multi-lateral well encompassing the steps of setting a diverter within a well-bore, boring through the sidewall of the well-bore at a desired location, lining the lateral well, and cementing the periphery of the junction around the lateral well to obtain a pressure-bearing seal around the well-bore. Conventional cementing techniques are disclosed to inject cement or an elastomeric cement in the interstices about the junction. One difficulty encountered when utilizing this method is ensuring a homogeneous filling with cement at the periphery of the junction because of the presence of tubulars and the limited space between the tubulars and the formation about the junction. Another common difficulty is ensuring a uniform fill of the cement about the junction without leaving spaces or voids because of the irregular shape of the interstices area about the junction. Accordingly, this method does not necessarily provide a homogeneous cement bond around a lateral well. Therefore the art field desires a method of effectively sealing the lateral well-bore from the primary well-bore.

Another difficulty encountered with the prior art method disclosed in the '503 patent is the practical impossibility of the method to effectually warranty the seal of the junction with the passage of time. The method discloses using conventional techniques to cement about the junction, such as flowing cement into the well-bore and allowing the cement to fill the interstices area between the liner and the lateral well-bore as the cement fills from below the junction. However, the amount of cement is limited to the cement that will fill within the interstices area around the junction between the casing and the formation. Accordingly, mud pockets that are not filled with the cement would result in structural weakness of the junction. As well, the dirt and debris from the formation can easily contaminate the cement as it fills the interstices

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Therefore, the art field desires a method that effectively fills the area where a junction is to be established by providing a sufficient amount of a cement or resin material to ensure an adequate volume of the cement or resin down-hole about a junction.

A prior art cement that has proven effective in resisting cracks and fissures is disclosed in U.S. Patent Nos. 5,795,924 to Chatterji et al. (the '924 patent), 5,820,670 to Chatterji et al. (the '670 patent) and 6,006,835 to Onan et al (the '835 patent). These prior art methods generally disclose an epoxy resin material or cement slushy that may be used in a well-bore. Numerous advantages have been found from the use of such epoxy resin materials. Some of the advantages are the reduced cracking from stress through the life of the well. Accordingly, the art field desires a method of drilling a lateral well that is able to realize benefits of a cement or resin material that resists cracks and fissures.

Typically, prior art multi-lateral wells with sealed junctions have required a large amount of underreaming of the primary well-bore to drill the lateral well-bore from the primary bore. Underreaming is the process whereby the primary well-bore is made wider, in this case, about the area where the lateral bore is desired. The increased width allows for room for the establishment of the junction and the lateral well. The underreaming is usually accomplished after a section milling operation has removed the casing about the area where the lateral bore is desired. Prior art operations have required the diameter of the underreaming to be about equivalent to 3.5 times the size of the primary well-bore. However, high ratio underreaming can be a risky operation, especially in highly deviated wells. Accordingly, the art field has searched for a method of drilling a multi-lateral well whereby the risks associated with underreaming may be reduced.

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As well, the prior art methods of drilling a multi-lateral well with a sealed junction have often required that the lateral well be of a smaller diameter than the primary well-bore. This reduction in size can severely limit further operations in the lateral well. Accordingly, the art field has searched for a method of drilling a lateral well whereby the diameter of the lateral well is not reduced from the diameter of the primary well-bore.

Therefore, what is needed in the art is a method of sealing a junction of the primary well and a lateral well to provide isolation of the lateral well-bore while maintaining an effective seal with the passage of time. Additionally, what is needed is a method of drilling the aforementioned lateral well-bore whereby the amount of under-reaming required to drill the lateral well is reduced.

SUMMARY OF THE INVENTION

The present invention generally relates to the an improved method of drilling multi-lateral wells, comprising filling a portion of a primary well-bore with a stress resistant cement or epoxy resin and drilling a lateral well from the primary well-bore whereby the substance used in the primary well-bore seals and isolates the formation about the lateral well-bore while allowing a lateral well to be drilled that is substantially the size of the primary well-bore. More particularly, the substance used to fill the area about the junction resists cracks and fissures and retains a seal through the passage of time.

BRIEF DESCRIPTION OF DRAWINGS

For a further understanding of the nature and objects of the present invention, reference should be made to the following detailed description, taken in conjunction with the accompanying drawings, in which like elements are given the same or analogous reference numbers and wherein:

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Fig. 1 is an illustration of an existing well-bore, cased and cemented.

Fig. 2 is an illustration of a well-bore where the casing has been milled out at the pre-selected location.

Fig. 3a is an illustration of an under-reamed area of an embodiment of the present invention.

Fig. 3b is an illustration of the prior art under-reaming operation.

Fig. 3c is an illustration of a top side view of the under-reaming required under embodiments of the present invention.

Fig. 3d is an illustration of a top side view of the under-reaming required under embodiments of the present invention and prior art methods of drilling.

Fig. 4a is an illustration of a pre-bent guide run into the well-bore at about the preselected under-reamed location.

Fig. 4b is an illustration of a pre-bent guide with an inflatable packer element run into the well-bore at about the preselected under-reamed location.

Fig. 4c is an illustration of a guide run into the well-bore at about the preselected under-reamed location.

Fig. 4d is an illustration of a guide with an inflatable packer element run into the well-bore at about the preselected under-reamed location.

Fig. 5a is an illustration of an embodiment of the present invention where an epoxy material has been injected into the well-bore to fill about the preselected under-reamed location with a pre-bent guide..

Fig. 5b is an illustration of an embodiment of the present invention where an epoxy material has been injected into the well-bore to fill about the preselected under-reamed location with a straight guide.

Fig. 6a is an illustration of an embodiment of the present invention where a path is drilled through the hardened epoxy along the pre-bent guide path.

Fig. 6b is an illustration of an embodiment of the present invention where a path is drilled through the hardened epoxy along the guide path.

Fig. 7 is an illustration of a completed drill path through a preselected location.

Fig. 8 is an illustration of an orienting sleeve and whipstock in the drill path.

Fig. 9 is an illustration of an embodiment of the present invention whereby a lateral well-bore is drilled.

Fig. 10 is an illustration of a completed lateral bore.

Fig. 11 is an illustration of the completed lateral bore with a liner installed.

Fig. 12 is an illustration of the completed, lined lateral bore with a bridge installed.

Fig. 13 is an illustration of the completed, lined, bridged lateral bore where the whipstock has been removed.

GENERAL DESCRIPTION AND PREFERRED MODE FOR CARRYING OUT THE INVENTION

Referring now to **Fig. 1**, an existing primary well-bore, cased and cemented, a typical down-hole well is illustrated. This embodiment is a vertical well, however, it should be understood that embodiments of the present invention work with well-bores that are not cased or lined, not cemented and not vertical. Embodiments of the present invention are designed for application wherever a stress resistant, sealed junction is desired out of an existing primary well-bore.

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Fig. 1 generally describes an area where a lateral well is desired. The figure is illustrative of a well that is completed with steel casing 1 and cement 2 around well-bore 3. The manner of selection of an area to drill a lateral well-bore may be by any means common in the art, however, most typically the selected location is where an operator desires to drill a new well, drill to a new target. However, this list is not exhaustive and there are numerous other reasons an operator may desire to drill a lateral well. The area selected for the lateral well is generally defined as preselected location 6.

In a preferred embodiment of this invention, as illustrated by Fig. 2, an illustration of a well-bore where the casing 1 has been removed at the pre-selected location 6, the well-bore 3 is prepared for drilling a lateral well. A specific and usually predetermined length of casing has been milled out, thus exposing cement 2 or a formation along the area desired to drill the lateral well-bore.

Section milling is common in the art. However, an exemplary section milling operation will be described briefly. An embodiment of a section milling operation in an existing well-bore 3 may include the steps of lowering a drill string 7 into the well bore 3, the drill string 7 having a conventional section mill 8 operateably attached about the drill string 7. In a preferred embodiment, the section mill 8 will be stopped above the preselected location 6 and begin downward section milling. The section milling may and should cause the section mill 8 to engage the casing 1 and destroy substantially all of the casing 1 about the pre-selected location 6. An operator may thus lower the drill string 7 to a point below the preselected point while keeping the section mill engaged thereby destroying or removing the casing from a point above the preselected location 6 to a point below the preselected location 6. After completion of the

section milling step, the operator should have removed substantially all of the casing along location 6.

Fig. 3b, an illustration of an embodiment of the prior art under-reaming operation, demonstrates the enlarging of the well-bore width 13 to an under-reamed width 17. In one embodiment of the present invention, it is necessary to under-ream a well-bore to a diameter of about 3.5 times the diameter of the well-bore to enable a lateral well-bore to be drill off the primary well-bore 3. Embodiments of the present invention are designed for establishing a lateral well-bore from any sized well-bore and under-reamed area. A preferred embodiment of the present invention utilizes an under-reamed area that is only about two to 2.5 times the diameter of the well-bore.

In **Fig. 3a**, an illustration of an embodiment of the present inventions under-reaming operation, it may be observed that well-bore width 13 is only enlarged to under-reamed width 12. It may be further observed that the ratio of under-reamed width 12 to borehole width 13 of **Fig. 3a** is smaller than the ratio of under-reamed width 17 to borehole width 13 of **Fig. 3b**. In a preferred embodiment of the present invention, as depicted in **Fig. 3a**, the ratio of under-reamed width 12 to borehole width 13 is about 2.0 to 2.5 whereas prior art ratios and ratios of embodiments of this invention, as depicted in **Fig. 3b**, of under-reamed ratio of width 17 to borehole width 13 is about 3.5. Accordingly, embodiments of the present invention do not require as much of an under-reaming operation. As previously discussed, a large under-reaming operation typically removes much of the formation about the borehole 3, as depicted in **Fig. 3b**. Accordingly, under the guidelines of embodiments of the present invention, the formation and existing well-bore 3 will not have as much of the formation removed by an under-reaming

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operation. The manner of achieving the reduced underreaming is depicted in Fig. 3c and Fig. 3d and will be more succinctly described below.

The remainder of this description of a preferred embodiment of the method of the present invention will utilize the underreaming of Fig. 3a where the ratio of underreamed width 12 to borehole width 13 is about two to 2.5.

Now referring to Fig. 4a, an illustration of pre-bent guide run into the well-bore at about the preselected location, it may be observed that the pre-bent guide 26 is not straight along the path of well-bore 3, but rather is arcuate at about the preselected location 6, returning to about straight along the remaining path of well-bore 3 at the lower end of preselected location 6. In an embodiment of the present invention a preselected guide is lowered into the well-bore 3 to provide an arcuate guide at about the preselected location 6. However, embodiments of the present invention may be used with a straight guide 27 running through well-bore 3, as illustrated in Fig. 4c. The guide 27 may extend through preselected location 6.

Now referring to Fig. 4b, an illustration of a pre-bent guide with an inflatable packer element run into the well-bore at about the preselected underreamed location, it may be observed that the pre-bent guide 26 is surrounded by an inflatable packer element 18. Further, pre-bent guide 26 is not straight along the path of well-bore 3, but rather is arcuate at about the preselected location 6, returning to about straight along the remaining path of well-bore 3 at the lower end of preselected location 6. In this embodiment of the present invention a preselected guide is lowered into the well-bore 3 to provide an arcuate guide at about the preselected location 6. However, embodiments of the present invention may be used with a straight guide running through well-bore 3, as illustrated in Fig. 4d. In an embodiment with a straight guide 27, an inflatable packer element 19 may also be utilized.

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Now referring to **Fig. 5a**, an illustration of an embodiment of the present invention where a cement 41 material has been injected into the well-bore to fill about the preselected location 6, it may be observed that a guide 26 still defines an arcuate path and the cement 41 has completely filled about the pre-bent guide. Another embodiment utilizes an epoxy cement material produced from a pumpable material of epichlorohydrin and bisphenol that hardens after injection into the well-bore 3. This epoxy resin and its derivatives are common in the art and are known to provide a high degree of impermeability while providing flexibility for shifts in the formation, unlike conventional methods or conventional cement. Often, these epoxy resin materials will include a liquid diluent containing a substance to allow the epoxy to have a sufficient viscosity to allow the epoxy material to be pumped into the well-bore 3 and completely fill about the preselected location 6. As well, another preferred embodiment of the present invention utilizes an additive within the material pumped to change the time of hardening of the cement. The additive may either be a retardant to prevent premature hardening or setting up of the material within the well-bore or an accelerator to hasten the hardening of the cement.

A most preferred embodiment of the present invention utilizes a pre-bent guide 26 (as depicted in **Fig. 4b**) that is surrounded by an inflatable packer 18. The inflatable packer 18 is typically constructed of an elastic substance such as rubber or an elastomer. However, any material may be used that stretches section milling four times the diameter of the packer element. The inflatable packer 18 is preferably about the pre-bent guide 26 in the area of preselected location 6 where the lateral well-bore is desired. After the underreaming operation, the packer may be inflated (not shown) such that the inflation completely fills the under-reamed area. Inflation of packers is common in the art and may be accomplished as known in the art. A

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typical method of inflating a packer pumps cement or other substance into the packer to inflate, a preferred substance is an epoxy resin such as an armoured epoxy.

The use of inflatable packer 18 on the pre-bent guide 26 will ensure that upon inflation no contaminant from the formation will become mixed with the cement and reduce the hardening of the material and sealing effect about the junction and also will ensure that the under-reamed cavity is substantially filled with a cement or epoxy resin material.

Referring now to Fig. 6a, an illustration of an embodiment of the present invention where a path is drilled through the hardened cement 41 along the guide path with a pilot mill 37, it may be observed that a path about the size of the primary well-bore is drilled through the epoxy at the preselected location 6 along guide 26 to re-establish well-bore 3. Apparatuses and drill strings are common in the art to drill along a curved path. Fig. 6b illustrates an embodiment of the present invention drilling along a straight guide 27 with pilot mill 37 attached to drill string 36 to establish a sealed well-bore and re-establish primary bore 3.

The remainder of the written description will illustrate embodiments of the present invention utilizing the arcuate drill path 44. However, embodiments of the present invention may utilize a straight drill path without any arcuate shape.

Referring now to Fig. 7, an illustration of a completed drill path through a preselected location, it may be observed that a continuous path 44 can be drilled along the guide 26 of Fig. 4 in well-bore 3. The drill path 44 of Fig. 8 will be sealed in the cement 41 material and will have a higher degree of strength and resiliency than the common cement methods because the cement was allowed to fill the entire area of the under-reamed section rather than filling in the interstices of the well-bore 3. This complete fill of the under-reamed area ensures that the junction may be machined down-hole through the filled under-reamed area.

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Referring now to Fig. 8, an illustration of an orienting sleeve and whipstock in the drill path, it may be observed that a sleeve 47 and whipstock 46 may be aligned within the drill path 44 within the preselected location 6. In a preferred embodiment of the method, an orientation sleeve 47 is lowered, oriented and anchored in well-bore 3 and a whipstock 46 is then placed about the sleeve 47 such that an angle 50 may be created away from the drill path 44. Angle 50 may be any angle that an operator desires according to the well plan.

Referring now to Fig. 9, an illustration of an embodiment of the present invention whereby a lateral well-bore is drilled, it may be observed that the new or lateral well-bore 61 may be drilled without requiring excessive space to make the transition from the primary well-bore 3 to the lateral well-bore 61 because of the arcuate fashion of the drill path 44. Drill string 56 may be lowered to whipstock 57 where it will be deflected into cement 41 to begin drilling a lateral well-bore 61. In a preferred embodiment of the method, lateral well-bore 61 may be drilled out of preselected location 6 into a desired formation or payzone to begin regular drilling operations.

Referring now to Fig. 3c, an illustration of a top side view of the underreaming required under embodiments of the present invention, the illustration of a cross-sectional cut 9 of Fig. 3a, it may be better seen that the area of underreaming may be reduced to about two to 2.5 times the diameter of the well-bore with use of embodiments of the present invention. primary well-bore 14 is shown as it extends above and below the cemented area of reduced under-reamed area 24. The new primary bore 15 is established after drilling along the pre-bent guide and the lateral well 61 is shown. The running of the pre-bent guide, as depicted in Fig. 4, allows the primary well-bore 14 to be off-centered within the reduced under-reamed area 24 when the new primary bore 15 is re-established by shifting the path of the primary well-bore 3. Essentially, the arcuate pre-

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bent guide shifts the well-bore from the general center of the under-reamed area towards the side. This off-centering allows the new primary well-bore 15, when re-established, to make full use of the reduced under-reamed area 24. Therefore, after the deflection is run, as depicted in Fig. 8, the lateral well-bore 61 may be established within the reduced under-reamed area 24. However, embodiments of the present invention still achieve the many benefits of the invention without a reduced under-reamed area.

Other embodiments of the present invention utilize various other under-reamed widths as depicted in Fig. 3d. It may be observed that under-reaming area 25 is about 3.0 times the diameter of primary well-bore 3. Typically, a straight guide (not shown) will be used to establish the primary bore-hole 3 along the path of the previously existing well-bore. In such a configuration, lateral well-bore 19 requires an under-reamed width of about 3.0 times the diameter of the primary well-bore 3.

As well, embodiments of the present invention allow the lateral well 61 to be drilled to a diameter that is substantially equivalent to the diameter of the primary well-bore 3. As such, the lateral well 61 is compatible with conventional drilling methods and equipment and does not jeopardize future operations.

Embodiments of the present invention are designed to be used with prior art drilling operations, the drilling operations not requiring any special modifications before implementation. Embodiments of the present invention produce a lateral well-bore that is substantially the same size as that of the primary well-bore or the existing bore from which the lateral bore was drilled.

For a further understanding of the integration of the present invention into common well plans, reference should be had to Fig. 10, Fig. 11, Fig. 12, and Fig. 13. Fig. 10 is an illustration of a drilled lateral well 61 with the drill string removed. From this point, regular drilling

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operations may begin. It is common in the art for a liner 65 to be hung in a lateral well 61 after completion as shown in **Fig. 11**. Further, it is common in the art to employ a bridge 66 at the liner as depicted in **Fig. 12**. Finally, as depicted in **Fig. 13**, the whipstock 46 may be retrieved. This results in two selectively accessible well-bores whereby the lateral well bore's diameter is of comparable size to the primary well-bore.. In a preferred embodiment, the orienting sleeve 47 is a pass through sleeve such that a drill string may pass through the sleeve 47 and enter the primary well-bore 3.

It is noted that the embodiment of the Improved Method for Drilling Multi-Lateral Wells and Related Device described herein in detail is only for exemplary purposes and is of course subject to many different variations in structure, design, application and methodology. Because many varying and different embodiments may be made within the scope of the inventive concept(s) herein taught, and because many modifications may be made in the embodiment herein detailed in accordance with the descriptive requirements of the law, it is to be understood that the details herein are to be interpreted as illustrative and not in a limiting sense.

CLAIMS

What is claimed is:

1. A new and improved method of drilling a lateral well from a primary well-bore, the well-bore junction sealed, comprising the steps of:
 - under-reaming a portion of the well-bore;
 - running a guide into the well-bore, the guide having an inflatable packer, the guide aligned substantially within the portion under-reamed;
 - inflating the inflatable packer, the inflatable packer inflated by a cement, the inflatable packer substantially filling the area under-reamed about the guide;
 - drilling out a section of the inflated packer along the guide such that a re-established well-bore is at least partially along the portion;
 - placing a deflection device along the portion of the re-established well-bore; and,
 - drilling a lateral well whereby the lateral well is sealed about the portion of the well-bore.
2. The new and improved method of Claim 1 wherein the cement is an epoxy material.
3. The new and improved method of Claim 1 wherein the step of placing the deflection device in the arcuate portion further comprises lowering a sleeve into the well-bore to the arcuate portion, the sleeve securing along the arcuate portion.
4. The new and improved method of Claim 3 wherein the sleeve is at least partially hollow, the sleeve allowing a drill string to pass through the at least partially hollow portion.
5. The new and improved method of Claim 3 wherein the step of placing the deflection device further comprises lowering a whipstock to the sleeve.
6. The new and improved method of Claim 4 wherein the whipstock may be selectively oriented to a plurality of locations.

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7. The method of Claim 2 wherein the epoxy is an armoured epoxy.
8. The method of Claim 1 wherein the inflatable packer expands to about 4 times a diameter of the inflatable packer.
9. The method of Claim 1 wherein the cement includes an additive, the additive changing the time of hardening of the cement.
10. The method of Claim 9 wherein the additive increases the time of hardening of the cement.
11. The method of Claim 9 wherein the additive decreases the time of hardening of the cement
12. A new and improved method for establishing a second well-bore, the method comprising the steps of:
 - plugging a first well-bore about a section of the first well-bore;
 - filling the section of the first well-bore with a cement such that the section of the well-bore is substantially filled with the cement; and,
 - drilling out the cement to establish the second well-bore, the cement sealing and isolating the section of the well-bore.
13. The method of Claim 12 wherein the cement is an epoxy material.
14. The method of Claim 13 wherein the epoxy is an armoured epoxy.
15. The method of Claim 12 wherein the plugging of the first well bore further comprises plugging with an inflatable packer.
16. The method of Claim 12 wherein the plugging of the first well-bore is at a pre-selected location.

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17. A new and improved method of drilling a lateral well comprising the steps of under-reaming a portion of a first well-bore, running a guide into at least a portion of the first well-bore, filling the portion of the first well-bore about the guide with an epoxy, establishing a second well-bore about the guide, and drilling a lateral well-bore from the second well-bore wherein the epoxy seals the junction about the lateral well.
18. The method of Claim 17 wherein the guide is lowered in the well-bore to about the portion under-reamed, the guide having a pre-bent section lowered at the portion under-reamed.
19. The method of Claim 18 wherein the step of establishing a second well-bore further comprises drilling along the pre-bent guide such that the second well-bore is partially arcuate about the portion under-reamed
20. The method of Claim 17 further comprising lowering a sleeve and whipstock to the portion under-reamed.
21. The method of Claim 17 wherein the epoxy is an armoured epoxy.
22. The method of Claim 17 wherein the guide comprises an inflatable packer.

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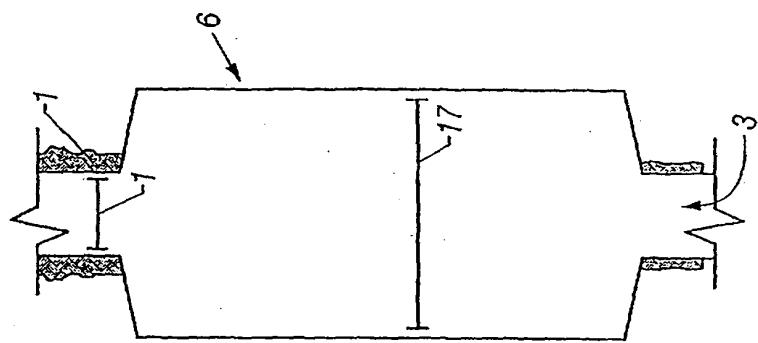


FIG. 3B

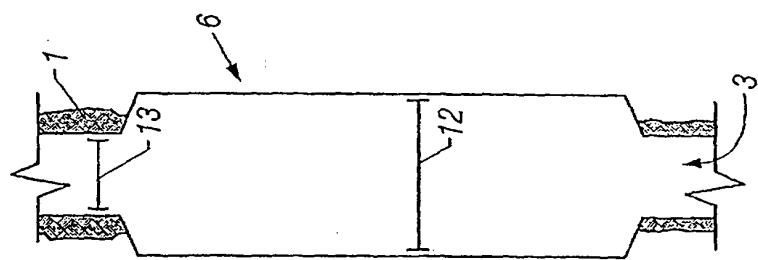


FIG. 3A

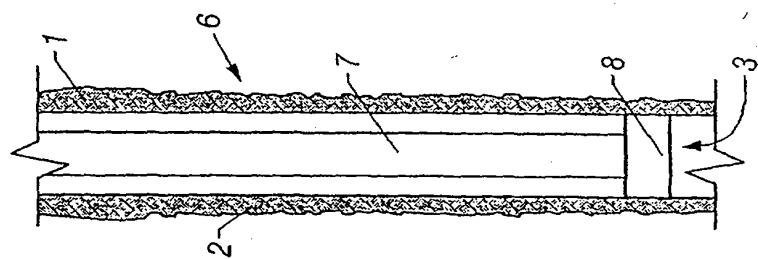


FIG. 2

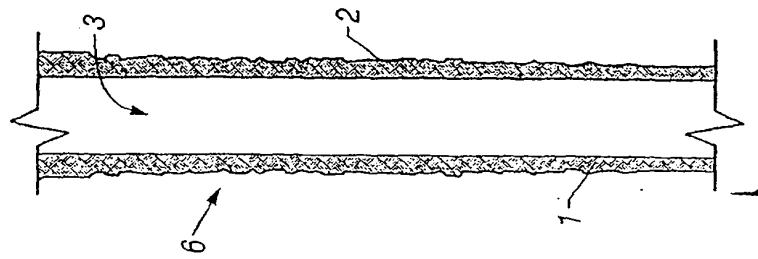


FIG. 1

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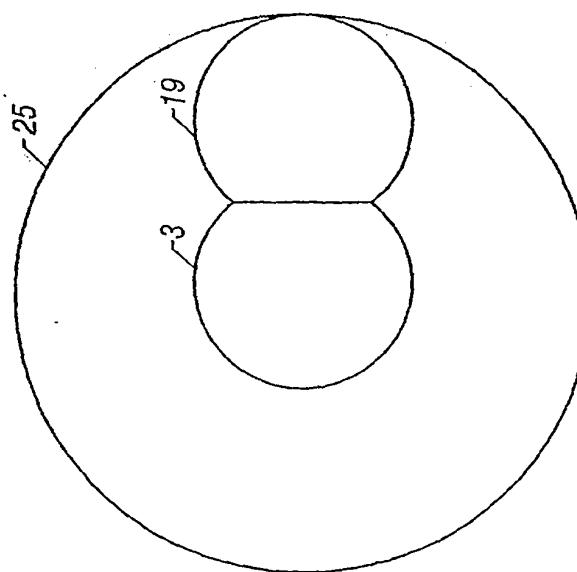


FIG. 3D

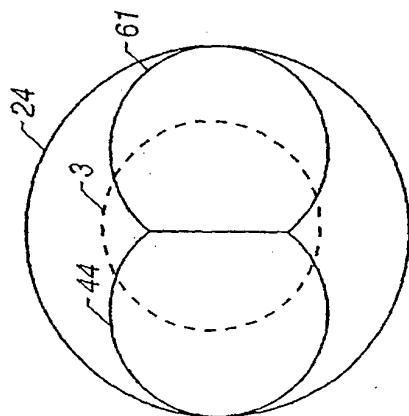


FIG. 3C

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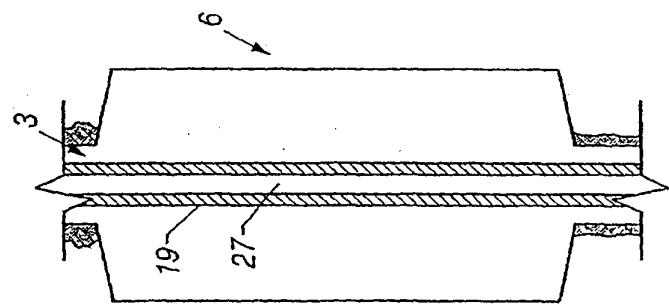


FIG. 4D

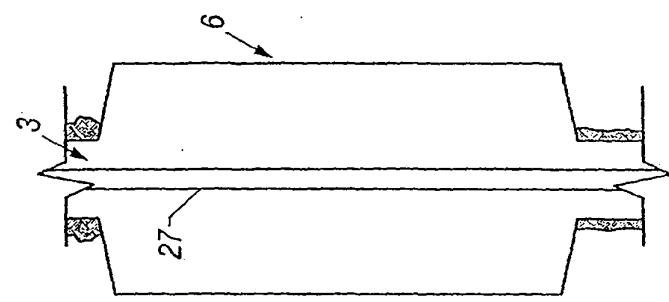


FIG. 4C

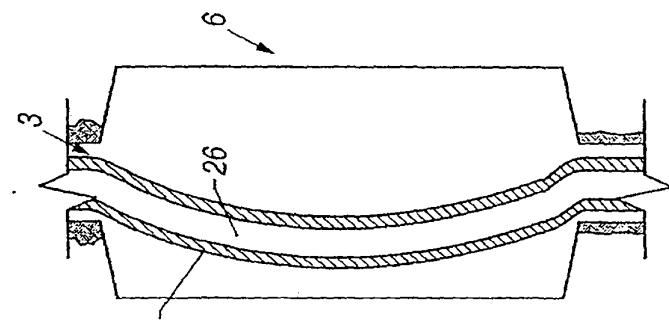


FIG. 4B

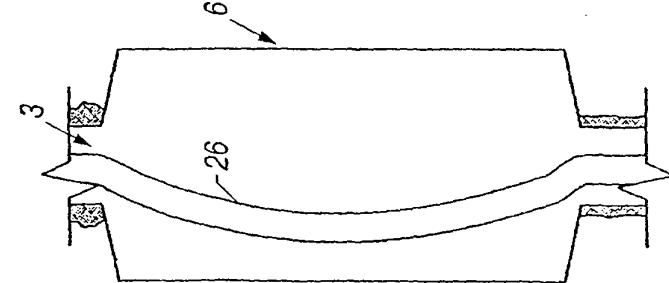


FIG. 4A

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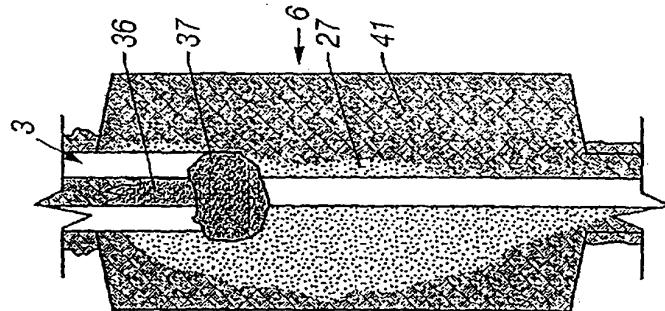


FIG. 6B

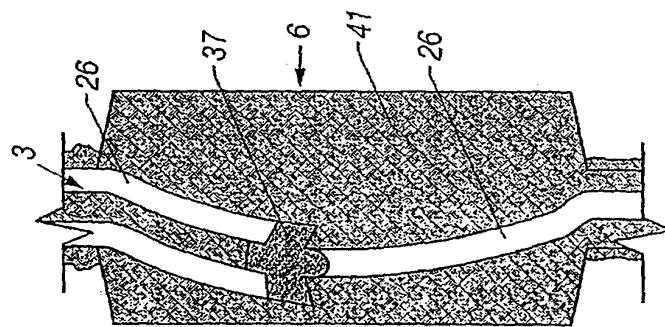


FIG. 6A

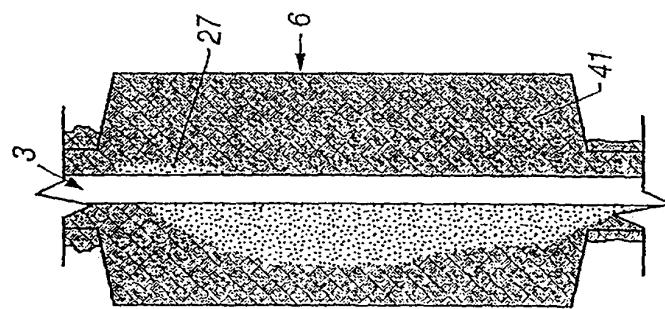


FIG. 5B

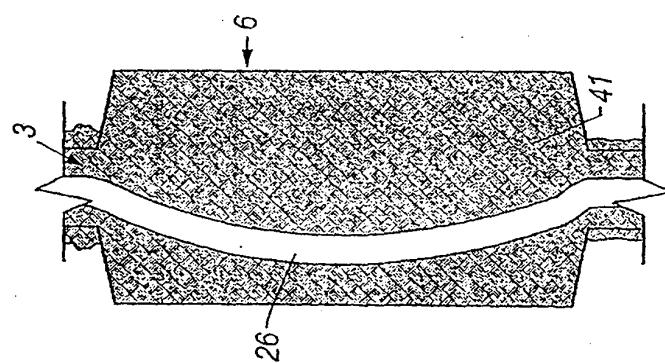


FIG. 5A

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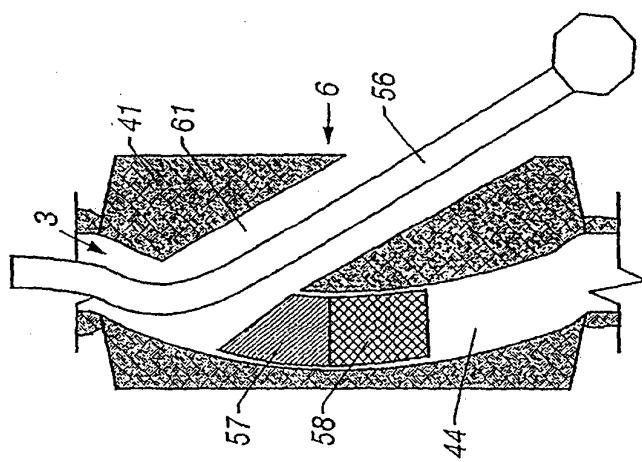


FIG. 9

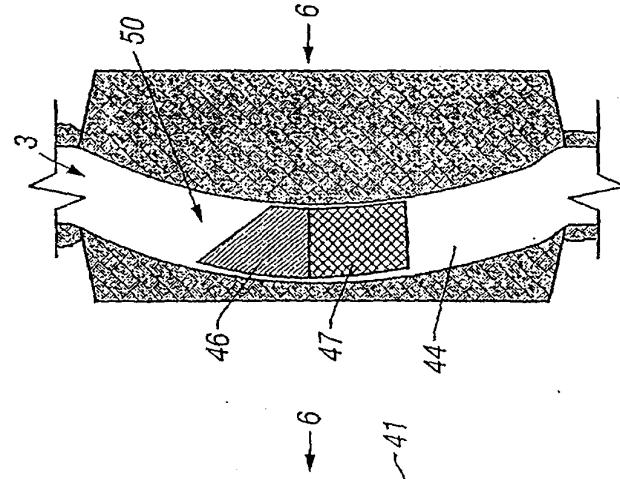


FIG. 8

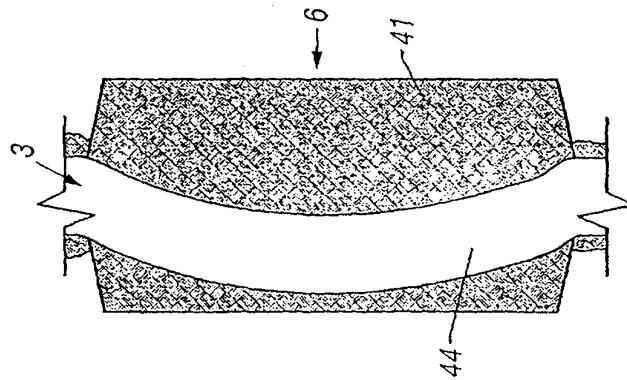


FIG. 7

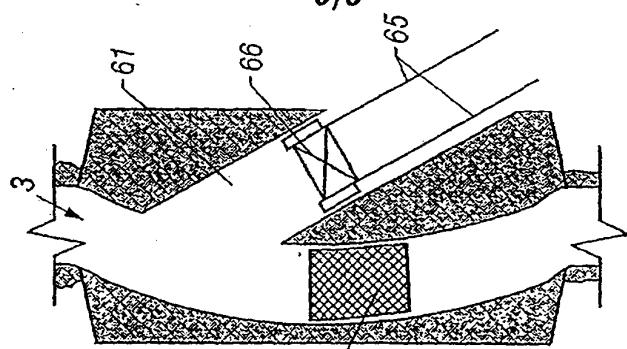
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FIG. 13

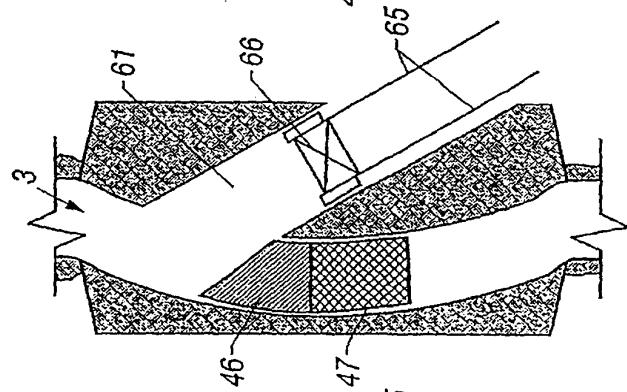


FIG. 12

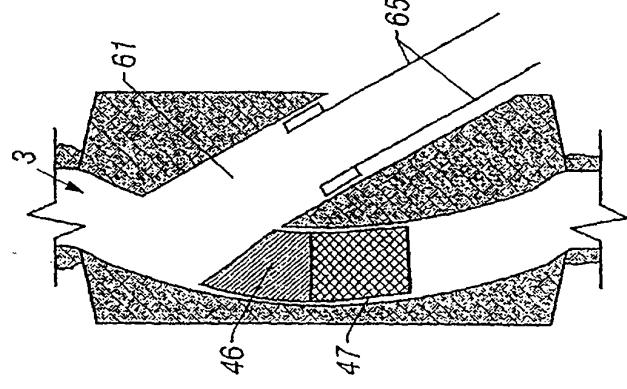


FIG. 11

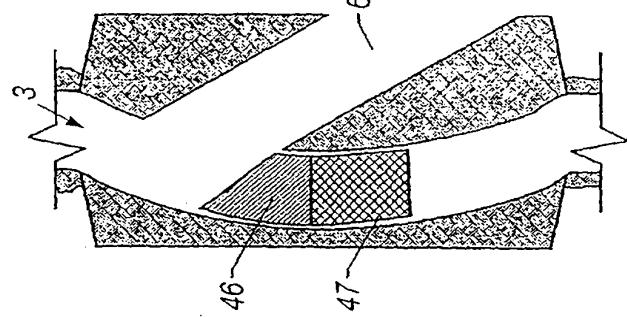


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/41914

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :E21B 7/04
US CL :166/50, 117.6; 175/61, 80

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 166/50, 117.6; 175/61, 79, 80, 81, 82

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,462,120 A (GONDOUNIN) 31 October 1995 (10/31/95), see Figure 10 and column 16, line 11 through column 17, line 10.	1,3-6,8,12,15, 16
Y		2 , 7 - 11,13,14,17,20-22
Y	US 6,006,835 A (ONAN et al) 28 December 1999 (28/12/99), see the abstract.	2,7,13,14,17,20-22
Y	US 5,544,705 A (JONES et al) 13 August 1996 (13/08/96), see column 1, line 53 through column 2, line 41).	9-11
A	US 2,173,035 A (ARMENTROUT et al) 12 September 1939 (12/09/39), see the entire patent.	1-22

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"		document defining the general state of the art which is not considered to be of particular relevance
"E"		earlier document published on or after the international filing date
"L"		document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O"		document referring to an oral disclosure, use, exhibition or other means
"P"		document published prior to the international filing date but later than the priority date claimed
	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
	"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 SEPTEMBER 2001	05 NOV 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer HOANG DANG <i>Diane Smith f</i> Telephone No. (703) 308-2168

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DOCID: <WO_0218738A1_I>

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/41914

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,937,955 A (NIMS et al) 17 August 1999 (17/08/99), see the entire patent.	1-22

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